The Basis of Fuel Management on State Forest in NSW

PETER F. MOORE AND BRETT SHIELDS
(Communicated by H.A. Martin)

State Forests of NSW, Fire Management Branch, Locked Bag 23, Pennant Hills NSW 2120

MOORE, P.F. AND SHIELDS, B. (1996). The basis of fuel management on state forest in NSW. Proc. Linn. Soc. N.S.W. 116: 115–126

Fuel management has been practiced in NSW State forests since 1891 and forms an integral part of State Forests approach to fire management. State Forests believes the system of prioritised fuel management zones it has evolved, and continues to adapt as circumstances warrant, is the best combination of fuel management approaches needed to carry out its role within the community, meet its requirements under external legislation and fulfil its charter to the Forestry Act (1916).

Manuscript received 23 Jul 1995, accepted for publication 20 Sep 1995.

KEYWORDS: wildfire, hazard reduction, prescribed burning, fire management, fuel management

INTRODUCTION

State Forests, formerly known as the Forestry Commission of NSW, is a government trading enterprise that evolved as a result of restructuring, to fulfil the role of forest management in NSW.

State Forests is responsible for the management and protection of approximately 3.5 million hectares of dedicated State forest, and is also responsible for the management of timber on a further 3.7 million hectares of Crown-timber land (Table 1).

State Forests' corporate mission is to manage forests in an environmentally responsible manner, supplying products and services to meet customer expectations and achieve a commercial return.

Vital to the role of forest management is the protection of the community and forests from the adverse effects of uncontrolled wildfire.

TABLE 1

New South Wales Forest Area Statistics from 1993–94

Total area of NSW	80,000,000 ha
Forests in New South Wales	15,017,000 ha
Forests as percentage of State's area	18.7%
State forests	3,488,000 ha
Forests in National parks and Reserves	2,577,000 ha
Forests on other Crown land	3,696,000 ha
Forests on private land	5,256,000 ha

The protection of the community and forests from wildfire was first initiated by forest managers responding to the community and forest requirements from as far back as 1891 (Grant 1989). Since that time many lessons have been learned and recorded in regard to fuel management in NSW forests.

Legislation now documents the regulations guiding fuel management activities in NSW. Within this legislative framework there are some basic principles of fire management which should be acknowledged so that fuel management can be placed in perspective.

Implicit to fuel management, is an understanding of the link between fuel and fire behaviour. Fire is the result of the combination of three features, commonly referred to as the fire triangle. These feature are a source of fuel, a source of oxygen and a source of heat (ignition).

In a forest environment the fuel source is both the living and dead plant matter. The source of oxygen is the atmosphere and the source of ignition can be from deliberate or accidental ignition or a natural cause such as lightning.

If any one of these factors can be removed from the fire triangle, the fire will cease. Fuel is the only practical feature of the fire triangle that can be either removed or modified in a forest environment. Whilst natural causes of ignition cannot be prevented, concerted effort is placed on community education to reduce the risk of deliberate or accidental ignition.

Hazard reduction burning in rural NSW is the most practical and widely used method by which forest fuel is modified. Hazard reduction burning modifies the fuel in two ways. Firstly, it reduces the volume of fuel available to a wildfire, thereby reducing fire intensity (Luke and McArthur 1978). Secondly, it changes the fuel arrangement on the forest floor and just above the floor, which bears a strong influence on reducing the intensity of a wildfire (Chandler et al. 1983, Cheney 1981).

The reduction of intensity of a wildfire reduces the risk of injury to rural firefighters, the community, commercial forest products and sensitive forest environments.

Hazard reduction burning plans are carried out over broad forest areas, to account for the needs of protection for rural communities, parks and reserves, commercial forest products or particular forest features that require special attention in relation to fuel or fire management.

A case example of the planning procedure is used to examine the fuel management planning process and features accounted for when planning fuel management.

Genesis of Fuel Management in NSW

State forests in NSW have been managed by a government agency for more than 100 years. Prior to the initiation of the Forest Conservancy Branch in 1877, regulations governing forests were aimed at ensuring adequate amounts of timber were left for government purposes (Hannah 1986).

The agencies governing the forests between 1877 and 1909 were many and varied, but did not attempt to formulate or implement policy on forest management or protection (Hannah 1986). However, within that time period fuel and fire management began to take shape. The Forestry Act (1909) created the Department of Forestry but was superseded by the Forestry Act (1916) which promulgated the Forestry Commission of NSW. As recently as 1991 the Forestry Commission underwent a restructure to form a government trading enterprise and renamed the organisation State Forests.

State Forests of NSW, then the Forestry Commission, has had a long and extensive history of fuel and fire management in NSW and is a lead agency in this field. The Bushfires Act (1949) was first written by a Forestry Commission manager, and the more recent 1989 amendments to the Act were formulated from input and submissions by State Forests' predecessor.

Fire management techniques such as the use of fire breaks were being developed and implemented as early as 1912, by the then Department of Forestry, while the first use

of prescribed burning was conducted in 1891 (Grant 1989). The first Fire Control Schools, began in 1947. These schools involved a seven day series of lectures and demonstrations on weather forecasting, fire control legislation, radio communications and methods of bushfire fighting (Grant 1989). The first fire control schools also taught the preparation and value of fire control plans. The fire control schools that began in 1947 have formed a strong basis for the more detailed fuel and fire management plans now used by land management agencies.

State Forests Role in Fuel Management

State Forests believes it is essential that the community be aware that fire is a constant and inevitable aspect of forest management. Mindful of the vital role of, and need for, community fire fighting, State Forests has assumed responsibility for significant aspects of community fire protection, particularly in country New South Wales.

State Forests operates to a charter as set out in the Forestry Act (1916). This charter puts forth the objective of State Forests to:

- conserve and utilise the timber on Crown-timber lands to the best advantage of the State
- provide adequate supplies of timber from Crown-lands for building, commercial, industrial, agricultural, mining and domestic purposes
- preserve and improve, in accordance with good forestry practice, the soil resources and water catchment capabilities of Crown-timber lands
- encourage the use of timber derived from trees grown in the State and consistent with the use of State forests for the purpose of forestry, flora reserves and the preservation of flora, promote and encourage State forests use for recreation and conservation of fauna.

In the attainment of these objectives, and in the exercise of its duties and functions, State Forests is required to take all practical steps which it considers necessary, or desirable, to ensure the preservation and enhancement of the quality of the environment.

Further, the Forestry Act (1916) also states that subject to the Bush Fires Act (1949), State Forests may carry out on Crown-timber lands measures for the protection from fire of timber and products on Crown-timber lands.

State Forests manages the forest estate under its control with the aim of serving a wide range of conservation, community and commercial needs. This aim requires that State Forests be committed to ecologically sustainable management and dedicated to the conservation of all aspects of the forest environment.

Underpinning the protection of the community, timber resources, water catchment, soil, flora and fauna is the development and maintenance of a successful fuel and fire management regime.

Role of Legislation in Fuel Management

State Forests fuel and fire management planning is guided by extensive legislation, including:

Bush Fires Act (1949)
Forestry Act (1916)
National Parks and Wildlife Act (1974)
Environment Planning and Assessment Act (1979)
Clean Air Act (1961)
Occupational Health and Safety Act (1983)
Endangered Fauna (Interim Protection) Act (1991)
Workers Compensation (Bush Fire Emergency and Rescue Services) Act (1987)
Crimes Act (1900)
Local Government Act (1918).

Meeting the functions of all of these Acts is a complex task. However, the long history of State Forests' role in fuel and fire management and its experience in both planning and fulfilling these tasks have provided State Forests with the capability to balance the objectives of impinging legislation.

The Bush Fires Act (1949) has been written to make provision for the prevention, control and suppression of bush fires, and for the mitigation of dangers resulting from bush fires. Further the act provides the primary impetus for conducting fuel management activities on rural lands, including State forest. The Forestry Act (1916) requires that timber and products on State Forests and Crown-timber lands are adequately protected from fire and that the measures undertaken to protect these values are consistent with good forestry practice.

The majority of the Acts prescribe a framework within which fuel management and fire suppression can be carried out. However, within the legislative framework the Bush Fires Act (1949) has primacy over nearly all other Acts, because the community places the value of protecting life and property very high.

FUEL MANAGEMENT

For the purposes of the Bush Fires Act (1949) New South Wales is divided into local government areas (LGA). Each LGA has a Bush Fire Management Committee comprising of members from the local community and land management agencies. This committee compiles a plan of operations and, a plan of fuel management for the LGA. The plan of operations outlines the method for suppressing bush fires, and the fuel management plan prescribes the measures by which fuel management shall be undertaken.

Objective of Fuel Management

The primary objective of fuel management is not to eliminate wildfire, which is impossible, but rather to create a mosaic of fire regimes and fuel such that the incidence and intensity of wildfire over the long term is reduced. Moderating the incidence and intensity of wildfire assists the protection of life and property while maintaining the integrity of the environment and helps protect commercial forest products.

It is widely recognised, both here and overseas, that fuel management — hazard reduction burning — makes it easier and safer to control fires (Chandler et al. 1983, Cheney 1981). Hazard reduction burning minimises the potential for severe wildfires, reduces fire management costs, and restricts wildfire damage on State forests and adjoining lands.

Further, State Forests rates hazard reduction burning as the best fire suppression training process available. It provides staff with important experience and awareness of fire behaviour, and the regular exposure to fire is a significant factor in maintaining fire readiness and a professionally developed fire culture.

State Forests specific fuel management objectives are:

- to protect life and property from wildfires
- to prevent the spread of wildfire onto neighbouring properties
- to protect assets on State Forest
- depending upon the assets to be protected, to provide a range of direct and indirect fire suppression options in the event of a wildfire
- to minimise damage to timber values on State Forests and other Crown-timber land
- to exclude fire from environmentally sensitive areas, for example a rainforest flora reserve
- to maintain biodiversity.

Fuel management — hazard reduction burning — reduces hazards in several ways:

- by reducing the total weight of fuels, the rate of spread and intensity of a fire is reduced, thereby reducing the impact of the fire upon forest values including soils, flora, fauna, water catchments and aesthetics.
- by reducing the height of the fuel bed, the flame height is reduced, thereby reducing the risk to firefighters and the impact on the forest
- by removing firebrand material, principally fibrous bark, the potential of wildfires to generate spot fires ahead of the main fire front is greatly reduced. (The reduction of spotting potential can reduce the overall rate of spread, and greatly increase the suppression capability and the safety of firefighters).

Several benefits follow from active fuel management, including:

- the opportunity to provide practical training for staff in fire behaviour, fire control techniques, fire safety measures and the use of a range of fire fighting equipment
- the establishment of good liaison and working relationships with forest neighbours, Bush Fire Brigades, councils and other authorities involved in co-operative hazard reduction burns along common boundaries for community and asset protection purposes
- to allow suppression resources, both firefighters and equipment, to be released from wildfires contained by effective hazard reduced areas.

Responsible fuel reduction does not aim to eliminate all readily flammable fuels. The correct timing of a hazard reduction burn, in conjunction with localised site variations in altitude and topography, moisture and vegetation cover, will commonly result in 30–50 per cent of the gross area being modified by the burn. The overall result is a reduction in fuel weight and arrangement on a proportion of the treated area, with a mosaic of burnt and unburnt areas.

Results of Fuel Management

Fuel management on a regional scale promotes a mosaic of fuel age, which maintains a lower average 'fine fuel' weight across the region. It also limits the vertical arrangement and continuity of fine fuel. These two effects combine to reduce the intensity of wildfire.

Fine fuel is the fuel that is less than six millimetres in diameter, and largely consists of leaves, twigs and bark. The coarser fuel, or heavy fuel, is modified slightly by hazard reduction burning.

The reason for targeting fine fuel in hazard reduction burning is because it is more volatile and the greatest contributor to a wildfire's intensity, as compared to the heavy fuel. Modification of the fine fuel provides the greatest benefit in reducing a wildfire's intensity, while minimising the impact on other values in the forest environment, such as timber, soil and water catchment values.

Low intensity hazard reduction burning generally reduces the fine fuel weight by up to 75 per cent over 30 to 60 per cent of the gross area being treated.

Following low intensity hazard reduction burning, the fine fuel weight will recover to 70–80 per cent of the pre burn weight in about 2–3 years. Whereas a high intensity wildfire will often reduce the fine fuel weight by more than 75 per cent, burn away heavier fuels and cover a higher proportion, approaching 100 per cent, of the area burnt over.

Fire Behaviour

The McArthur Forest Fire Danger Rating system provides a numerical fire danger index, ranging in scale from 0 to 100, as outlined in Table 2. The scale can be used to describe five classes of fire danger, ranging from low to extreme.

The fire danger index in conjunction with specific information about fuel weight, topography and forest type, allows predictions of fire behaviour to be made. Fire behaviour prediction will include features such as the rate of spread of the fire, flame height and possible spotting distance of a fire.

A prediction of fire behaviour is used during hazard reduction burning to ensure that the fire is a low intensity fire. Fire behaviour predictions are also used in wildfires to assist in the development of suppression strategies.

TABLE 2

Description of McArthur Forest Fire Danger Rating

Fire Danger Rating	Rating	Weather Description
Low	1–5	still wind, high humidity
Moderate	5–12	still to light wind, moderate humidity
High	12–24	moderate wind, moderate humidity
Very High	24–50	strong wind, low humidity
Extreme	50–100	strong and gusty wind, very low humidity

Planning Fuel Management

It would be impossible, and unacceptable, to conduct hazard reduction burning over the entire forest estate on an annual basis. Planning procedures have been developed to determine suitable priority zones which require fuel reduction. A number of factors which encompass the reasons for protection and fire behaviour are accounted for when determining priority zones, and include:

- value of asset to be protected
- wildfire history
- topography
- forest type
- weather — including temperature, relative humidity, drought factor and wind speed which provide a fire danger rating
- fuel loads (t/ha)
- fire spotting distance
- flame height
- rate of spread of fire.

Fuel management planning based on priority zones is a detailed method by which the forest manager can ensure that adequate protection is provided to neighbouring property, high value assets and forest values including timber, flora, fauna, soil and water catchments.

The case example uses these parameters to determine the objectives of fuel management related to the value of the asset to be protected and the fire behaviour that would be expected under the weather conditions generally experienced in the area.

Case Example of Fuel Management Planning

Experience has shown that five per cent of all wildfires account for 95 per cent of the damage incurred to assets (State Forests unpublished data). Also that this five per cent of fires tend to occur within 15 per cent of the highest fire danger rating days in an area.

Weather records for the case example area demonstrated that the 85th percentile (cut off point for the 15 per cent of highest fire danger rating days) recorded a Fire Danger Rating (FDR) of 30.

A FDR of 30 would typically combine weather parameters of 33°C temperature, 30 per cent relative humidity, and a 35 km/hr wind speed. Under these weather conditions a fire can be expected to behave quite differently for various fuel loads. Fuel load is a measure of the amount of fuel in a forest, expressed in t/ha.

Table 3a and 3b outline two different fire behaviour scenarios under different fuel loads comparing an FDR of 30 with a worst case scenario of a FDR of 100.

TABLES 3A AND 3B

Fire behaviour scenario using various fuel weights under an FDR of 30 and an FDR of 100.

Table 3a. FDR 30

Fuel load (t/ha)	Spotting Distance (km)	Flame Height (m)	Rate of Spread (km/hr)
5	0.3	2.5	0.17
10	0.8	5.5	0.34
15	1.5	9.5	0.51
20	2.2	13.3	0.72

Table 3b. FDR 100

Fuel load (t/ha)	Spotting Distance (km)	Flame Height (m)	Rate of Spread (km/hr)
5	1.9	6.0	0.56
10	3.8	14.0	1.11
15	6.0	Crown Fire	1.68
20	8.1	Crown Fire	2.39

These two tables illustrate the dangerous fire behaviour (flames up to 13 m or more, spotting distances more than 2 km and spreading forward at 700 m per hour) that is sustained at a FDR of 30. Significantly worse fire behaviour is apparent at a FDR of 100. Within the tables the dramatic reduction in fire behaviour as a result of fuel weight reduction is demonstrated at a FDR of 30. The flames are 5.5 m high at 10 t/ha and is unable to be directly attacked by firefighters. However, once the fuel weight is lowered to 5 t/ha the flame height is reduced to 2.5 m and is at the upper limit of direct attack by fire fighters.

The implications for protection of valuable assets are obvious and must involve the weight of fuel available to wildfires.

The case example determined five separate fuel management zones, of which each has a separate objective and fuel management regime. The five zones are:

- zone 1: community protection and protection of high value assets
- zone 2: strategic corridors
- zone 3: fuel management over broad areas of forest
- zone 4: burning for special or ecological purposes
- zone 5: fuels to be managed without burning or remain unmanaged.

Zone 1, Community Protection and Protection of High Value Assets

Purpose

To provide a high level of protection to life, property and other identified assets. This zone also includes post logging burning after harvesting where burning is necessary to reduce fuels and promote regeneration.

Aim

To maintain a fine fuel weight that is as low as possible

- to achieve up to 80% coverage in each burning unit in each operation
- to reduce fuel levels after harvesting by post logging burning
- to maximise fire suppression options, particularly direct fire suppression, this zone will generally absorb short distance spotting.

Zone Width

Based on a FDR of 30, the zone width should be approximately 300 metres to allow for a direct fire suppression effort. This zone will generally absorb burning embers from fires outside the zone. By maintaining low fuel loads, the flame height would be up to 3 m high and spotting distances of up to 300 m. The zone width would be adjusted to allow for slope and topography to take account of their effect on fire behaviour.

Burning Cycle

Burning cycle refers to how regular the same area will be hazard reduction burnt. The burning cycle in any one area will depend on the rate of fine fuel accumulation but will generally be considered in the range from 2–3 years or when fuel loads reach 5–8 t/ha. Post logging burning, will be conducted within 18 months after harvesting.

Applications

- community protection
- protection of adjoining plantations
- protection of adjacent rural land holdings
- protection along highway corridors.

Zone 2, Strategic Corridors

Purpose

To provide a strategic corridor which can act as a barrier to the spread of wildfire and assist in absorbing short distance spot fires. These corridors will complement zone 1 areas, particularly around community settlements, plantations and other high value assets.

Aim

- to provide a mosaic of fine fuel weights after burning of between 5–8 t/ha
- to achieve up to 60 per cent coverage in each burning unit in each operation
- burning under conditions when the lower layers of litter are moist to ensure that the nutrient rich litter and surface soil are not completely removed
- to maintain a thin layer of unburnt litter, preferably of 4–6 t/ha retained unburnt to minimise the effects on microfauna and flora
- to protect sheltered SE-aspects from fire in addition to gullies to provide refuge areas for fauna
- to maximise fire suppression options, but direct fire suppression as an option is not mandatory, this zone will generally absorb burning embers from fires outside the zone.

Zone Width

Based on a FDR of 30, the zone width should be approximately 800 m to allow some direct fire suppression effort in the event of a wildfire, however, indirect fire suppression methods such as backburning would be the main option. By maintaining a fuel load of 5–8 t/ha, flame height in the zone would be up to 5 m and spotting distance up to 800 m. In some instances, for example, adjacent to sensitive nature reserves or plantations, the zone width may be increased substantially (up to 3–4 km) to allow fire suppression within a crown fire free zone under a high FDR. The zone width would be adjusted to allow for slope and topography to take account of their effect on fire behaviour.

Burning Cycle

The burning cycle would depend on the rate of fine fuel accumulation but will generally be considered from 3–5 years or will be assessed when fuel loads reach 8–12 t/ha.

Applications

- corridor adjacent to zone 1 for protection of adjoining high value assets, such as plantations
- protection of adjacent rural land holdings with low density population
- corridor along highways
- provision of strategic corridors that will allow backburning in the event of a major wildfire.

Zone 3, Fuel Management Over Broad Areas of Forest

Purpose

Broad area fuel management is to act as a complement to other management objectives. In the broader forest area, where life and property are not directly at risk, fuel management will aim to provide a mosaic of burnt and unburnt areas that will still allow indirect fire suppression effort in the event of a wildfire, but also will maintain bio-diversity in the long term.

Aim

- to provide a mosaic of fine fuel weights after burning between 8–15 t/ha
- to maintain biodiversity
- to provide a mosaic of burnt and unburnt areas so there are no large contiguous areas of unmanaged fuel, this zone will complement the other zones as part of the protection over broad areas
- burning under conditions when the lower layers of litter are moist to ensure that the nutrient rich litter and surface soil are not completely removed
- to maintain a thin layer of unburnt litter, preferably of 4–6 t/ha, retained unburnt to minimise the effects on microfauna and flora
- to protect sheltered SE-aspects from fire in addition to gullies to provide refuge areas for fauna
- to achieve up to 60 per cent coverage in each burning unit in each operation.

Zone Width

Based on a FDR of 30, the fuels will be managed on a mosaic within a minimum zone width of 1.5 km and would still allow a range of indirect fire suppression options for fuel loads of up to 15 t/ha. The resulting flame height in wildfires under FDR 30 would be up to 9.5 m high and spotting distance up to 1.5 km.

Burning Cycle

The burning cycle will depend on the rate of fine fuel accumulation but will generally only be considered after a minimum of 6 years since the pervious burn or wildfire. Areas would be considered for burning in the 6–10 year time frame, or when fuel loads

reach 12 t/ha. If the fire regime requires a burning cycle of longer than 10 years, fuel loads should not exceed 15t/ha.

Applications

- fuel reduction over broad areas, under conditions where mainly ridge top fuels will burn
- as a precursor to logging to assist in achieving post logging burning objectives.

Zone 4, Burning for Special or Ecological Purposes

Purpose

To provide specific burning and fuel management requirements for a number of purposes, such as research into the effects of fire on the environment, management strategies to provide specific fauna habitat, burning for specific flora protection or burning under young regrowth.

Aim

To provide the conditions and treatments or implement the regimes detailed in management or fauna and flora recovery plans.

Burning Cycle

This will depend on the specific requirements of the plans.

Burning under regrowth

This will commence when the dominant and co-dominant trees have reached an average diameter of 10 cm. Burning will aim to avoid damage to the dominant and co-dominant trees in the regrowth stand, and maintain an average of 5–6 t/ha over the area. Burning would be carried out when the weather conditions are suitable, and generally include:

- air temperature up to 25°C
- relative humidity between 50%–80%
- mean wind speed in the open up to 15 km/hr
- near surface fuel moisture between 12%–20%

These are guidelines and will be refined over time with careful records of burning results and fire behaviour at the time of burning.

Fauna Management

Fire regimes will be considered for the specific requirements of the management plan or recovery plan developed for particular fauna species.

Flora Management

Fire regimes will be considered for the specific requirements of the management plan or recovery plan developed for particular flora species.

Zone 5, Fuels to be Managed Without Burning or Remain Unmanaged

Purpose

These are fuels in areas where management priorities require that prescribed burning is to be excluded or areas where fuels are to remain unmanaged.

Aim

To exclude deliberate ignition, wildfires or fuel management, as appropriate from these areas.

Applications

Typical applications include:

- rainforest areas
- drainage and creek line filterstrips

- areas of significant historical, research or archaeological value
- rare or threatened plant species that are sensitive to fire
- most flora reserves.

In some cases the areas in this zone will need to be actively protected from fire and may be bound by zone 1. or zone 2.

CASE EXAMPLE AREA

The case example depicts a fire regime for an area of State forest just under 140,000 ha in size (Table 4). This State forest area like most in NSW is not isolated but is adjoined by other lands including national park, reserves, crown land and many hundreds of private land owners. There are many assets surrounding and within the forest area including community settlements, single dwellings and plantations, which all require protection from fire.

Several features of the case example need to be highlighted:

- the average repeat burning cycle over the total area is 12 years
- 2% of the total forest area has a repeat burning cycle of less than 3 years of which 60% of the area treated each year is burnt
- 28% of the total forest area has a repeat burning cycle of less than 7 years, of which 60%–80% is actually burnt
- 26% of the total forest area is not planned for burning or will be only burnt for ecological or special purposes.

TABLE 4

Annual area burnt within case example

Zone	(a) Total area within each forest zone (ha)	% of area in zone	(b) Burning cycle	% of total treated annually	(c) Planned burn coverage within each zone	(a/b) x (c) Annual area actually burnt (ha)
1. Community Protection	2,896	2%	1–3, av.2	1%	80%	1,158
2. Strategic Corridors	35,695	26%	3–5, av.4	6%	60%	5,354
3. Broad Area	48,953	35%	6–10, av.8	4%	60%	3,671
	16,060	11%	>10, av.12	1%	60%	803
4. Special or Ecological Burning	18,253	13%	Variable assume av.8	2%	Variable assume 50%	1,140
5. No Burning	17,961	13%				
Total	**139,818**					**12,126**

SUMMARY

State Forests believes that it consistently demonstrates a professional approach to fuel and fire management. The combination of a highly qualified and experienced staff, together with the operational, technical and managerial skills developed in fuel manage-

ment, has created an effective and efficient fire culture to satisfy the imperatives of legislation, meet the objectives of State Forests' charter to the Forestry Act (1916) and carry out the vital role of community fire protection.

The fuel management planning zones developed by State Forests are a comprehensive method by which community protection, commercial forest products and the forest environment can be maintained and adapted as circumstances warrant.

REFERENCES

Chandler, C., Cheney, P. Thomas, P., Trabaud, L. and Williams, D. (1983). 'Fire in Forestry: Volume 1, Forest Fire Behaviour and Effects'. (John Wiley & Sons: New York).

Cheney, P. (1981). Fire Behaviour. In 'Fire and the Australian Biota' (Eds. A.M. Gill, R.H. Groves and I.R. Noble). (Australian Academy of Science: Canberra).

Grant, T.C. (1989). 'History of Forestry in NSW, 1788–1988'. (Star Printery: Erskineville, NSW).

Hannah, H. (1986). 'Forest Giants: Timbergetting in New South Wales Forests, 1800–1950'. (Forestry Commission of NSW: Sydney).

Luke, R.H. and McArthur, A.G. (1978). 'Bushfires in Australia'. (Australian Government Publishing Service: Canberra).